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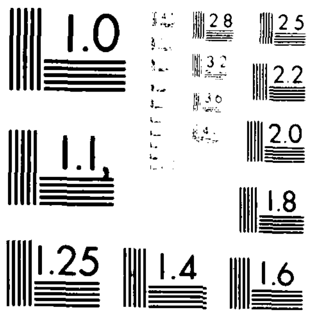

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FOREIGN TECHNOLOGY DIVISION

HORIZONS OF TECHNOLOGY

(Selected Articles)

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GRAPHICS DISCLAIMER

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TELECOMMUNICATIONS CABLES

by Zdzislaw Perkowski

The level of telecommunications depends upon the number of circuits in the telecommunication network. In Poland, the amount of telecommunications cables placed in the country influence this. Regardless of the possible use of optical signals as information carriers (as well as light waves and optical cables as transmission sources), traditional telecommunications cables (with copper or aluminium wire) will be used further in the network.

Long range telecommunication cables serve for the transmission of electric signals functioning as information carriers.

Cables' basic elements are wires of which the majority are separately insulated. Individually insulated wires comprise a group, of which the most important are: coaxial pairs, symmetrical pairs and symmetrical radial tetrads. The symmetrical groups (for ex. a radial pair or tetrad) are the so-called tie wires, coiled from two or four identical insulated wires. The coaxial pairs contain one insulated wire called the internal wire on which is placed the external coaxial cylindrical wire.

From the point of view of the transmission of electric signals in a multiwire cable, it is possible to distinguish a certain number of electrical pilot lines. These are--independent of others--the paths of electrical energy. It is possible to send electrical signals along each electrical line in the cable from separate sources placed at the cable's end, to an independent receiver, situated at the cable' other end. In a cable containing insulated conductive elements it is possible to create n-1 electrical paths. However, in practice only part of the possible paths is used, with strictly defined properties.

A shift of the variable electromagnetic field or electromagnetic waves accompanies the transmission of electric signals along conductive paths. This phenomenon, which appears during the transmission of electromagnetic waves in the atmosphere, is observed in the conductive line as the damping or reflection of the waves.

Part of the energy of the electromagnetic waves is absorbed and emitted in the form of heat in the wires' conductive material, and in the insulation material (dielectric loss), and furthermore--a small part of the energy penetrates outward. If the observed wave-conducting line is situated in a multiwire cable, that part of the wave energy penetrating outwardly appears in the cable's other conductive lines.

The set of properties of the conductive line which fully characterizes the transmission of electromagnetic waves lengthwise along the line is called the line's transmission properties, and those of the line determining the penetration of part of the waves' energy outwards--the coupling properties. Like wave transmission in the atmosphere, the change of transmission conditions and hence, also of the transmission properties of the conductive line over a certain finite distance, causes the final energy. The reflected waves return in the direction of the signal's source and unfavorably affect the line's properties. The line in which these appear is heterogeneous. In practice, one attempts to obtain the least energy possible from the reflected wave. This means the creation of a homogenous line.

In a multiwire cable for signal transmission, lines are exclusively used with very good transmission and coupling properties. The requirements concerning the lines' coupling properties are sometimes so copious that they cannot be met without using screens--metal bands, which encompass a strictly defined group of insulated wires. This limits to a significant degree the penetration of electromagnetic energy from the conductive line located inside the screen to the outside and the reverse.

The groups of coiled wires are in the core of the cable, on which--for long range cables--is installed metal sheathing. Protective casing protects the metal sheathing against corrosion and against accidental damage--a plate of steel bands or steel wire. It is also secured against corrosion by an additional casing.

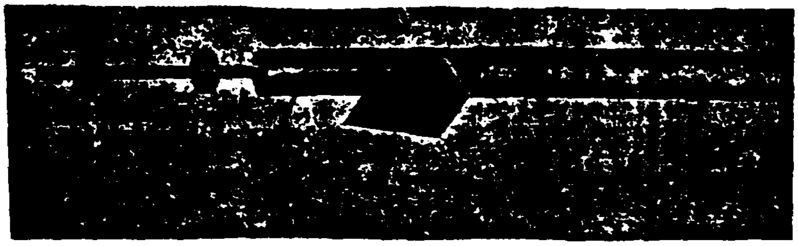
MULTIPLE TELEPHONY

Conductive lines of long range cables, both coaxial and symmetrical, are used for the transmission of multiple telephony. This means that several telephone conversations are transmitted along one line. Two multiplication systems are used: with frequency division and with temporal division. The first utilizes the shift of the spectrum of the successive telephone transmissions to greater frequencies by means of the so-called carrier waves' modulation, owing to which the spectrums of the successive telephone conversations occupy on frequency scales adjacent sectors 4 KHz wide. A signal obtained this way, acting as the carrier of several conversations, is, without further transformation, directed to the line. Such a signal is called an analog which is why systems of telephony with multiple frequencies are also called analog systems.

Multiplication with temporal divisions (the PCM system), which has seen broad application only in recent years as the consequence of the appearance of integrated circuits with a larger scale of integration, is based on the analog signal's rather complex treatment (p. HT 7/72) which leads to the signal's transmutation within a series of impulses, called the digital signal.

CABLES WITH COAXIAL PAIRS

The production of long range cables with normal sized coaxial pairs (2.6/9.5 mm) was begun at the start of the 1960s according to the original Polish technology. The coaxial pairs produced in the country met the international requirements of the day and were initially used for 1920 X analog telephony and later also for 2700 X telephony.



Ill. 1. coaxial pair of normal dimensions 2.6/9.55 mm · 1-internal wire 2-internal wire's insulation (polyethylene discs, 3-external wire, 4- screen (steel band), 5-external insulation (paper tape)

The coaxial pair's external wire is made from copper with a diameter from 2.639 to 2.640 mm **Polyethylene** discs placed uniformly at intervals of 27 mm constitute the insulation formed directly on the wire--by injecting liquid polyethylene into the forms which encompass the wire.

The external wire is made of 31.0 $\pm$ .1 mm wide and .25 $\pm$ .01 mm thick copper bands coiled in a tube with a lengthwise aperture, strengthened by two spirally wound steel bands which at the same time play a role as an electromagnetic screen. Each coaxial pair has also a so-called external insulation with two spirally wound paper tapes(ill 1).

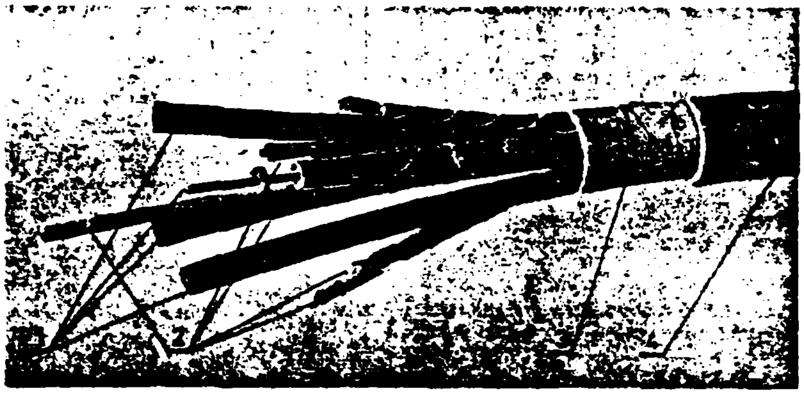
The material consumed in producing normal size coaxial pairs has caused their usage for the transmission of 2700 X telephony to become uneconomical. To achieve this same goal, coaxial pairs with the smaller dimensions of 1.2/4.4 mm can be used, with 4 times smaller mass of copper accounting for the unit of length. Because of this, efforts have been made to modernize the construction and technology of the production of 2.6/9.5 mm coaxial pairs in order to adapt them to the transmission of 10,800 X analog telephony, within a frequency range of about 64 MHz (which is entering already into the range of radiophonic ultra short waves).

Introductory research has indicated that, owing to drawbacks concerning production technology, heterogeneity appears in coaxial pairs causing the reflection of waves with frequencies of around 45 MHz. This worsens transmission quality. Hence, changes in production technology in the construction screens for coaxial pairs were needed. The early screens--made of two steel bands wound spirally in the same direction did not guarentee good coupling properties for the coaxial pair above 30 MHz. Only the use of a double layered, spiral screen (patent PRL nr. 96309) radically improved these properties in a frequency range of several GHz. Presently, cables with four and six 2.6/9.5 coaxial pairs adapted to the simultaneous transmission of 10,800 telephone calls are being produced. Traditional leaded sheathing protected from corrosion by housings pressed from thermoplastic materials are now produced.

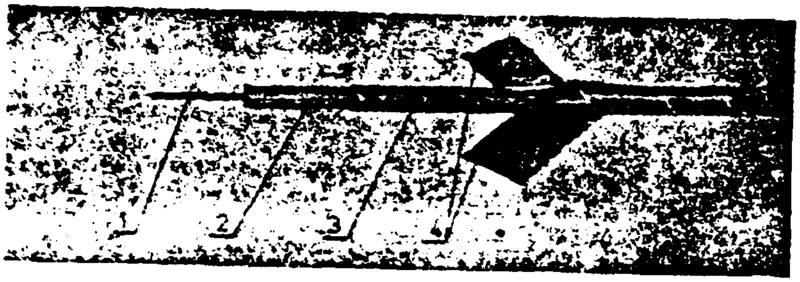
In addition to that described above, long range cable with smaller size coaxial pairs is also being produced.

The internal cable of the smaller size coaxial pair (1.2/4.4 mm) is composed of copper wire (1.18 mm diameter) on which is placed a polyethylene tube (inner diameter 4.4 mm thickness .4 mm) by a screw extruder press for thermoplastic material.

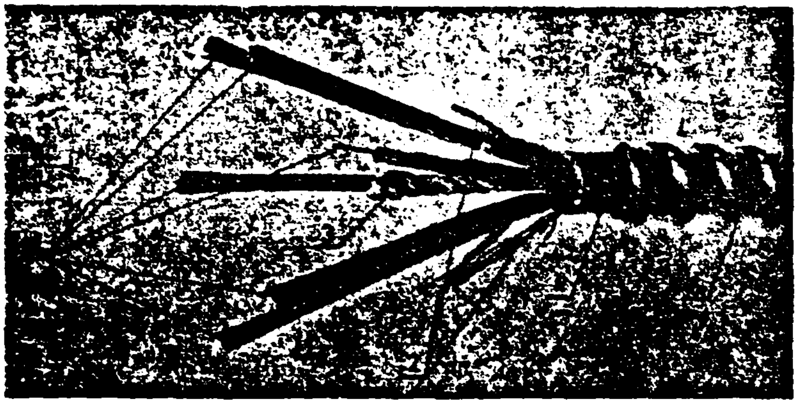
This tube, in a plastic state, is, before cooling, tightened cyclically on the wire by a shaping apparatus, forming "baloon" insulation (ill. 3).



Ill. 2. Long range cable with 4 coaxial pairs of normal dimension for 10,800 X telephony: 1. coaxial pairs, 2. symmetrical service bunches, 3. core casing (paper tape), 4. leaded sheathing



Ill. 3. Smaller size (1.2 4.4 mm) coaxial pair: 1-internal cable 2. "balloon" insulation, 3. external cable, 4. screen of steel, copper bands



Ill. 4 Long range cable with 6 smaller size coaxial pairs for 2700 X telephony: 1. coaxial pairs, 2. symmetrical service bundles, 3. core filling (polyethylene string), 4. protective core covering (paper tape), 5. waved aluminium sheating

The external cable is a tube with lengthwise aperture, wound with copper bands. It is mechanically strengthened by two copper steel bands, wound in opposite directions, which simultaneously play the role of electromagnetic shield, securing the coaxial pair against the penetration into its inside of disturbances from without (also from other coaxial pairs in the same cable).

Ill. 5. Long range cable composed of 24 symmetrical pairs for digital transmission 8.5/34 Mbits/s: 1-pairs of 1 of the screen bunches according to a screen picture, 2. screen bundles (6 pairs) 3. auxiliary pairs, 4. protective core covering (paper tape), 5. waved aluminium sheathing

The small size coaxial pair is a very economical transmission means; with a four times less consumption of copper per distance unit, the transmission and coupling properties will allow its usage in a 2700 X analog system or PCM.

Serially produced cable cores contain 4, 6, 8 or 12 coaxial pairs, 3 tetradic symmetrical bundles for service communications and signalling, and one line serving to localize cable damage (in cyclically damaged polyethylene insulation). Thanks to the insulation's damage, water, coming in contact with the cable causes a short, signalling cable damage.

All cores are wound spirally with several layers of paper tape. The circuit of paper tape guarantees a greater puncture voltage between the core's metal elements and the metal sheathing (important during atomospheric discharges). Moreover, with the installation of the metal sheathing, it acts as heat insulation, preventing the penetration of an excessive amount of heat into the core, which could damage it (the insulation is chiefly of polyethylene).

The cables are produced in aluminium sheathing, smooth (only with four coaxial pairs) or spiral waves (ill. 4) in order to increase flexibility.

In order to protect against corrosion, the sheathing is covered with a layer of elastic bitumen (a mixture of asphalt and synthetic rubber). On this layer is usually embossed a casing of polyethylene, resistant to aging, to the effects of light and to so-called stress corrosion (cracking under mechanical pressure in superficially active media, for ex. in detergents).

CABLES FOR PCM SYSTEMS

In addition to the types presented here, telecommunications cables are produced with symmetrical lines. Cable is also produced with lines for digital transmission with a binary flow capacity of 8.5 or 34 megabits per second (corresponding to 120 or 480 telephone channels per line).

The copper wires of such cables (with a diameter of.8mm) are insulated with a frothy polyethylene, and are subsequently twisted into pairs. From six of such bundles with various twist intervals, is formed a bunch wound with two aluminium bands (an electromagnetic screen). The cables' cores can contain 4 (ill. 5), 8 or 14 such bundles and an auxiliary pair.

The cores' wrapping, the waved aluminium sheathing, the protective casings and armor of these cables have a structure identical to that of cables with small dimensioned coaxial pairs.

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IONIZING RADIATION UNITS

Radioactive substances or those whose atoms are not stable, because nuclear changes occur in them, behave in various ways--they show unequal activity. Their size is measured in units called by the eminent French physiscist (Antoine Henri Becquerel)--becquerels. The radioactive body shows an activity equal to one becquerel (1 Bq) if one nuclear change occurs in it each second: 1 Bq=1:1 s.

Often, it is necessary to measure the energy absorbed by the irradiated body or the energy emitted by the radioactive substance. The dose absorbed is measure in greys (Gy). The value of 1 Gy is equivalent to when a body with a mass of 1 kg is exposed to an energy equalling 1 J, hence 1 Gy= 1 J;1 kg. The exposure dose (irradiation) is an exposure dose of photon radiation, for which a charge of ions formed in dry air is equal to one coulomb, and the electrons, released by the radiation's photons into a space which contains of kg of air, lose their ion exchange ability. This rather lengthy definition is written in the simple form of the radiation's exposure ratio or 1 C/kg=1 C: 1 kg.

There are also various units of the force of the absorbed dose and of the exposure dose. Both amounts are defined as a ratio of the corresponding dose to time. There is a certain analogy here to mechanical force. A Gy per second is the force unit, for which the dose absorbed equal to 1 Gy is created in one second: 1 Gy/s=1 Gy : 1 s. The force of an exposure dose is defined in amperes per kilogram; this slightly surprising form results from a simple coulomb-ampere ratio: 1 A=1 C/1 s. An ampere per kilogram is the force of the photon radiation exposure dose, for which the exposure dose increases at 1 C/kg per second: 1 A/kg = 1 C/s : 1 kg.

With regard to radioactive bodies, the concept of flux density is employed. It is measured per square meter times seconds, and the unit is meters to the minus square power times seconds to the minus first power. The flux density of ionizing particles is when one ionizing particle enters in one second into a sphere with a surface area of 1 m^2 (the surface of a sector formed by the plane intersecting the sphere and passing through its center):
$1\ m^{-2} \times s^{-1} = [1:1\ s]:1\ m^2$.

In addition to the units of ionizing radiation cited here which pertain to the SI system, other units are permitted for use. These include: the rad for measuring the absorbed dose--1 rad=.01 Gy; the curie (Ci) which appears as a unit of activity (1 Ci=3.7×10^{10} Bq) and the Roetgen (R) for the measurement of the exposure dose (1 R=2.58×10^{-4} A/kg). Also permitted are those units created by aid of the dose force unit (both for absorption and exposure).

ATTENTION, THE ENEMY KNOWS ALL OR ABOUT CIPHERGRAMS AND CRYPTOLOGY

In September a feature film was shown on our TVs about a rare interwar success of Polish intelligence, which--as is now said--"broke the unbreakable enigma," a machine for coding the Wehrmacht's messages. The discovery of the secret "Enigma" greatly contributed to the destruction of Hitler's Germany. We now are presenting a text on the history of ciphers and the technique of using them, which was printed in the West German magazine, Hobby.

Imagine such a picture as this: a slave kneels submissively in front of a tyrant and begs him, "Lord, cut my hair and look at my scalp." These words were told to Aristagoras, ruler of Milet, in 500 BC. the amazed Aristagoras fulfilled the slave's request and was dumbfounded when he saw on the slave's scalp a text written by his father-in-law, Histios. The secret message, smuggled on the slave-messanger's head called for a war against Darius, the emperor of Persia.

The history of war, national culture and the lives of great people is often irreparably tied to the fate of various secret missions, codes and cryptograms. The reception and transmission of important plans in secret became a great art and their deciphering, a still greater art.

The first mention of cryptography appears in the eighth centry BC. During the flowering of the Arabian school of mathematics, several methods and ways of arranging codes were devised. Three centuries later, the Spartans, while fighting wars, devised the first "device" for writing with a secret alphabet. That was a type of wooden cylinder with a definite center in which was placed papirus and twisted into the shape of a screw. Manipulating the papirus accordingly, a text was written on it, line by line. After twisting, its text was read by changing the position of the individual letters. Only by identically twisting the papirus was it possible to understand the contents.

The Romans devised a much simpler method: Caesar cleverly transposed by three letters his writing, so that for ex. D meant A. His successor, Augustus, was satisfied with an easier plan, shifting not three, but only one letter of the alphabet. Charles the Great took another tack. He devised several alphabets consisting of a few, simply fantastic characters. This was an infallible method (for ex. it was only in the 20th century that the correspondance of count Hatzfeld in the 30 Years War, written with various astrological and other symbols, was deciphered), but not quite satisfactory. In an era of such inventions, as the typewriter, radio and telegraph, they returned to the traditional, smallest information carriers: the letter and the digit. The already mentioned method of Caesar, the shifting of individual letters of the alphabet, became the prototype of contemporary computerized cryptograms.

We owe a debt to the Venetian doges for the further development of cryptography. In the 16th century the fashion ruled to form special bureaus in which worked educated, well paid "coders". These were generally respected people, surrounded by their own admirers. They had to give up their residence in the palace only when they provided the decoded text. This concept spread to the Vatican which organized a special "decoding service" and soon there was a coding expert in every prince's court in Europe.

In highly competitive periods, when neighbor tries to cheat neighbor and cousin tries to see his cousin's cards, such keys that existed ceased to be sufficient. Codes were then perfected and made more complicated. Coding and vocalic cypher keys were introduced. The Italian, Leon Alberti, constructed a kind of rotary dial, which allowed everyone to devise various alphabets and form numerous codes. The German abbot, Johannes Trithemius went still further.

the tabula recta--this was a multi-alphabetical system, in which another cipher was devised for each letter. The texts were encoded not only linearly but also by columns.

The more complicated the code, the more time was necessary to break it. Cryptoanalysts constructed special machines for writing, taking into account the frequency of the appearance of individual letters in the alphabet of the givenlanguage. For example in German the most frequent appearing vowel is "e" (16-18%). the total share of vowels and their frequency of appearance in written and spoken German is 40%. Hence, the simple calculation of the appearance of individual sound and groups of sounds can be a good indicator for cryptology. These analytical methods were continuously perfected, and other, even more difficult ones were developed; for example the calculation of probabilities, the plurality theory, which soon became a good working tool and ally of the cryptologist.

How valuable was the science of decoding secret texts, was shown especially during the two world wars. In January 1917, the German secretary of foreign affairs, Zimmermann, sent a telegram to the German embassy in the USA, in which he stated that Germany would attempt to persuade Mexico to enter into a war against the USA. Not only did the employees of the German embassy receive the telegram, but so did the English. It was decoded in the famous room #40 at London's naval intelligence. After this provocation, America declared war on Germany.

From World War II are best known the fate of the two "secret cryptological weapons": ENIGMA and ULTRA. Enigma (from the Greek) was built in 1927 by the German inventor, Artur Scherbius. After long consideration, he boasted that the Enigma code could not be broken. He forgot, however, that it could be acquired on the open market. The Polish security service did not miss the chance and soon several Polish specialists succeeded in solving the riddle of the "unbreakable Enigma." The secret of this encoding machine was given to the English and fell into the hands of the mathematical genius, Alan Turing. As a sort of answer to the building of Enigma was Ultra--a decoding machine known for its great speed. It performed a great service in demasking the German plans. In 1940 hitler's so-called "Operation Sea Lion" aimed at the invasion of the British Isles, was defeated thanks particularly to Ultra's decoding of secret radio orders.

The English carefully guarded their secret, not wanting to reveal even to the smallest degree the fact that they possessed the secret of Enigma. They had one reason for this--the complete decoding of German radio communications. In order not to arouse suspicion, the English more than once had to endure German air attacks. A drastic example is the ten hour bombing of Coventry. Although the English knew early on all the attack's individual plans, they decided (the then prime minister, W. Churchill decided) to sacrifice the city. The bombs completely destroyed the city, not sparing the population--that was the price for one day of the Ultra secret.

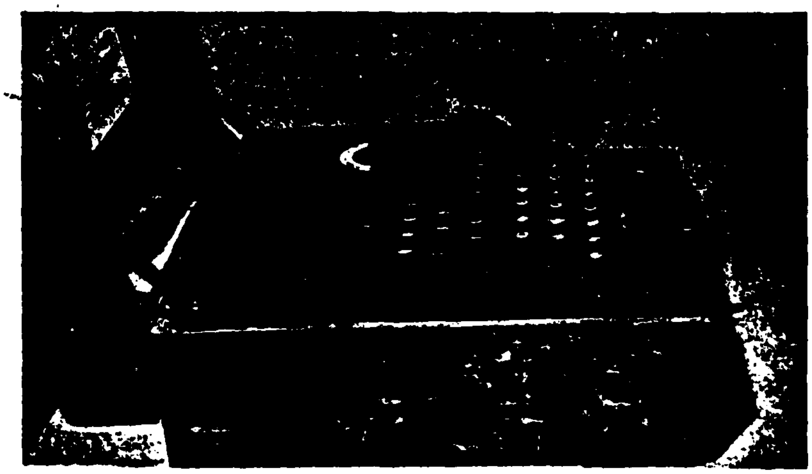

Illustration: The "Enigma"--the German coding machine from WW II, discovered after liberation. This machine is from the coolection of the Polish Military Museum.